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Correlation of Hearing Loss with the Site and Size of Tympanic Membrane Perforation

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Abstract **Original Research Article**

Objectives: This study was done to observe the relation of hearing loss with the site and size of tympanic membrane perforation. ***Methods:*** It was a prospective type of Observational study which was conducted at the Department of Otolaryngology and Head Neck Surgery, Uttara Adhunik Medical College Hospital, Dhaka during the period of May 2012 to October 2012 on patients that attended the outpatient department and also who were admitted in otolaryngology and head-neck surgery department. Total 200 patients (between 14 to 50 years of age) with perforated tympanic membrane in pars tensa were included by non-randomized purposive sampling. Among these patients 108 were male and 92 were female. They were categorized according to site and size of tympanic membrane perforation. Hearing threshold was assessed by pure tone audiometry. ***Results:*** According to size, there were small 44 (22%), medium 65 (32.5%), large 48 (24%) and subtotal /big central 43 (21.5%) perforations. According to location, there were anterior central 28 (14%), posterior central 35 (17.5%), central malleolar 94 (47.0%) and big central/subtotal 43 (21.5%) perforations. It was found that subtotal/big central perforations with the average bone conduction threshold 17.40 ±10.62 dB (SD), air conduction threshold 46.95 ±12.89 dB and air- bone gap 29.56 ± 5.85 dB caused more hearing loss than small and medium sized perforations. So it was seen that larger the perforation, more the hearing loss. Anterior central perforation had average bone conduction threshold 13.03 ± 3.61 dB, air conduction threshold 33.48 ± 4.81 dB and air-bone gap 20.86 ± 3.73 dB. Posterior central perforation had average bone conduction threshold 15.44 ± 7.38 dB, air conduction threshold 40.64 ± 10.34 dB and air-bone gap 25.11 ± 6.42 dB. This difference represent that posterior central perforation causes more hearing loss than that of anterior central. Hearing loss is also related to duration of perforation. Perforation for 0-5 years with the mean bone conduction threshold 11.71 ± 3.53 dB, air conduction threshold 32.36 ± 2.24 dB and air-bone gap 20.65 ± 3.92 dB. On the other hand perforations more than 20 years had the mean bone conduction threshold 17.27 ± 13.09 dB, air conduction threshold 46.38 ± 14.99 dB and air-bone gap 29.19 ± 9.09 dB. This difference shows that hearing loss is more in case of long standing perforation than the perforations of shorter duration. ***Conclusion:*** It was observed that hearing loss increases with the increasing size of tympanic membrane perforation. Posterior central perforation causes more hearing loss than anterior central perforation.

Keywords: Tympanic membrane perforation size, Tympanic membrane perforation site, Hearing loss.

INTRODUCTION

Hearing impairment is a major health problem all over the world. This disability affects the quality of life and has got considerable deteriorating effect on the family, social and economic aspect of life. According to WHO 360 million people (5.3% of the population of the world) live with disabling hearing loss. 32 million of these are children who are less than 15 years old. Disabling hearing loss refers to hearing loss greater than 40 dB in the better hearing ear in adults and a hearing loss greater than 30 dB in the better hearing ear in children (age < 15 years) [1]. Chronic otitis media is the predominant cause of tympanic membrane (TM) perforation and also a major health concern in many countries like India, Australia, and Tanzania [2].

The diagnosis of chronic otitis media implies a permanent abnormality of pars tensa or flaccida. Chronic otitis media may be of two types, tubotympanic disease and attico-antral disease. Tubo-tympanic disease is often the residue of acute suppurative otitis media and it is characterized by perforation of tympanic membrane situated in pars tensa sparing the fibrous annulus. Attico-antral disease is associated with cholesteatoma and tympanic membrane perforation situated in pars flaccida or marginally in the posterosuperior quadrant of the pars tensa with destruction of fibrous annulus [3].

Other causes of tympanic membrane perforation include trauma by foreign bodies in the ear, acoustic trauma (blast or loud sounds), barotrauma, physical assault and head injury. Barotrauma is stress exerted on the eardrum when the air pressure in the middle ear and the air pressure in the environment are out of balance. Barotrauma is most often caused by air pressure changes associated with air travel. Other events that can cause sudden changes in pressure and a ruptured eardrum include scuba diving and a direct blow to the ear, such as the impact of an automobile air bag. A loud sound or blast, as from an explosion or gunshot can cause a tear in the eardrum. Foreign objects in the ear like a cotton swab or bobby pin can puncture or tear the eardrum. Physical assault and severe head injury such as skull base fracture may cause dislocation or damage to the inner ear structures, middle ear structures and tympanic membrane.

Tympanic membrane is the partition between the external acoustic canal and the middle ear which is a very important part of sound transmission mechanism. It is slightly oval in shape with longest diameter from posterosuperior to anteroinferior is 9 – 10 mm, while perpendicular to this the shortest diameter is 8-9 mm [4]. Tympanic membrane can be divided into two parts: Pars Tensa and Pars Flaccida. Pars tensa forms most of tympanic membrane. Its periphery is thickened to form a fibrocartilaginous ring called the annulus tympanicus which fits in the tympanic sulcus. The central part of pars tensa is tented inwards at the level of the tip of Malleus and is called the umbo. A bright cone of light can be seen radiating from the tip of malleus to the periphery in the anteroinferior quadrant on a healthy tympanic membrane. Pars flaccida (Sharpnel's Membrane) is situated above the lateral process of malleus between the notch of Rivinus and the anterior and posterior malleal folds. It is not so taut and may appear slightly pinkish. Pars flaccida does not have tympanic annulus at its margin [5].

The tympanic membrane and the ossicular chain couples sound signals from the ear canal to the cochlea. The middle ear acts as a transformer to increase sound pressure at the footplate relative to that at the tympanic membrane at the expense of a decrease in stapes volume velocity relative to the tympanic membrane volume velocity. The major transformer mechanism within the middle ear is the ratio of the tympanic membrane area to the stapes footplate area (the area ratio). The tympanic membrane gathers force over its entire surface and then couples the gathered force to the smaller footplate of the stapes. Since pressure is force per area, and the human tympanic membrane has an area that is 20 times larger than the footplate, if the transformer action of the area ratio is "ideal," the sound pressure applied to the inner ear by the stapes footplate should be 20 times or 26 dB larger than the sound pressure at the tympanic membrane. Another transformer within the middle ear is the ossicular lever: the lever action that results from the different lengths of the rotating malleus and incus arms around the axis of rotation of the ossicles. The ratio of these lengths is 1.3, predicts only a small, 2 dB increase in sound pressure applied by the stapes to the inner ear. Thus, if these transformers acted ideally, then the 'theoretical middle ear sound pressure gain is about 28 dB (26 dB area ratio + 2 dB ossicular lever). The measured middle ear gain is less than 28 dB. The difference between the measured and theoretical gains is the result of several conditions within the middle ear that are not ideal all the time [6].

The effective stimulus to the inner ear is a difference in sound pressure between the oval and round windows. The middle ear maximizes this window pressure difference via two mechanisms: First, The tympano-ossicular system preferentially increases the sound pressure at the oval window of the inner ear. At the same time, the intact tympanic membrane reduces the sound pressure in the tympanic cavity by 10 to 20 dB compared with the sound pressure in the ear canal, thereby protecting or shielding the round window from the sound in the ear canal. These concepts of middle ear sound pressure gain, round window protection, and round window mobility have important practical implications for tympanoplasty [6].

When oval window is receiving wave of compression, the round window is at the phase of refraction. If the sound waves strike both windows simultaneously (because of loss of round window shielding effect due to perforation), they would cancel each other's effect with no movement of perilymph resulting hearing loss. This acoustic separation of windows is achieved by the presence of intact tympanic membrane and a cushion of air in the middle ear around the round window [5].

If the middle ear is disordered, transmission can change by way of several mechanisms. The stimulus may be inadequately coupled to the tympanic membrane, the impedance transformer action may be lost, the ability of the ossicles to move may be reduced and the differential application of sound pressure to the round and oval windows may be affected. A hole in the tympanic membrane will reduce the effective area of the membrane in contact with the sound wave. Holes will also reduce the pressure differential across the tympanic membrane and depending on their position, reduce the mechanical coupling between the remaining intact portions of the membrane and the malleus resulting hearing loss [7, 8].

Objectives

General Objective

To evaluate the relation of hearing loss with tympanic membrane perforation.

Specific objectives:

1. To detect the threshold of hearing in relation to site of TM perforation.
2. To detect the threshold of hearing in relation to size of TM perforation.
3. To detect the threshold of hearing in relation to duration of TM perforation.

LITERATURE REVIEW

Tympanic membrane perforation is a common defect that causes hearing loss. Site and size of the perforation are two important factors that affect the sound conduction mechanism. Alongside of these two factors duration of perforation is a factor that affects hearing. Regarding the site of perforation, it is believed that posterior perforations causes greater hearing loss than anterior perforations. Vijayshree Nahata *et al*., stated, "In our study it was observed that posterior perforations have the greatest hearing loss, that is, 39.99 ± 2.79 dB, followed by central perforation 35.64 ± 5.31 dB and anterior perforations, 30.1 ± 2.98 dB, respectively (*p* value 0.000)." In their study they also showed the relationship between size of tympanic membrane perforation and hearing loss. They showed that small perforation had 29.41 ± 4.39 dB; medium perforations, 34.69 ± 4.96 dB and large perforations, 38.79 ± 3.44 dB mean hearing loss which means that hearing loss increases with increased size of perforation [9]. Here posterior perforation and perforation involving central malleolar region causes more hearing loss than anterior one. This result is supported by Islam MS *et al*., They showed that posterior central perforations had high ear conduction threshold than anterior central perforations which is statistically significant. Besides they observed relation between duration of disease and hearing loss. According to them "Mean air conduction threshold for 0-5 years of disease was 38.18 dB (SD=6.81) and for 21-25 years mean air conduction threshold was 59 dB (SD=10.12). Difference between these two were statistically significant (t=5.88, p<0.001) [10]."

However some authors like Voss *et al*., said in their study "Our measurements showed no systematic differences between losses that resulted from perforations at different locations" [11]. Bob Lerut *et al*., supported this opinion, "location of perforation has no effect on hearing loss." They mentioned another important findings regarding size and site of perforation, "Umbo involvement in tympanic membrane perforation worsens the hearing significantly with 5.5 dB on mean ABG, meaning that whenever umbo is involved, 5.5 dB can be attributed to the loss of coupling and the rest of the ABG is caused by the fact that there is a perforation in the eardrum" [12].

Titus S Ibekwe and others stated that the location of perforation on the tympanic membrane had a significant impact in chronic tympanic membrane perforations but not in acute perforations [13].

Nepal A and others concluded regarding site and size, "Hearing loss was found to be directly proportional to the size of perforation irrespective of their cause, which was statistically significant. Conductive hearing loss in the study was found to range from negligible to 53 dB. Overall, perforations involving posteroinferior quadrant were found to have maximum hearing loss [14]".

Maharajan M *et al.,* stated, "The larger the perforation, the greater the decibel loss in sound perception. Large central perforations involving all four quadrants results in more degree of hearing loss. The location of perforation on the tympanic membrane has significant effect on hearing loss. Posterior placed perforations have greater degree of hearing loss. The conductive hearing loss resulting from tympanic membrane perforation is frequency dependent, with the largest losses occurring at lower frequencies. Duration of ear discharge also have significant effect on magnitude of hearing loss, the longer the duration of ear discharge the greater the hearing loss" [15].

C.L. Bhusal and others had wide observation on site of tympanic membrane perforation and its impact on hearing. They said, "A maximum hearing loss of 45 dB was observed in big central perforation and minimum hearing loss of 31 dB in anterior central perforation. There is no significant difference between big central perforation (45 dB) and posterior central perforation (43 dB). Hearing loss was almost equal in anterior central perforation (29.17 dB) and central malleolar perforation (29.5 dB). Posterior central perforation cause more hearing loss than anterior central ones" [16].

Rafique *et al*., observed regarding time of disease, "The mean degree of deafness increased as the time of disease increased and the difference was statistically significant" [17]. Yousry El- Sayed in his study stated that a relationship exists between uncomplicated CSOM and elevation of bone conduction. He showed statistically significant relation between duration of diseases and elevation of bone conduction. Disease less than 10 years had average bone conduction elevation 8.7 ± 5.7 dB and disease more than 20 years had average elevation 15.6 ± 8.1 dB. So mixed hearing loss is found in cases of long standing diseases [18].

Pannu *et al.*, in their study evaluated hearing loss and found that posterior perforation caused more hearing loss (36.29 ± 10.17 dB) than anterior perforation (31.56 ± 13.77 dB). They found statistically significant difference of hearing loss among small, medium and large perforations. Regarding Duration of disease they said, “All the perforations were divided into three groups according to duration of disease and hearing loss at each frequency was noted in all the three groups. Hearing loss at 250 Hz in group A (<1 year) was 32.58 ± 12.51 dB and in group B (1-5 years) it was 37.02 ± 12.55 dB and in group C (>5 years) 45.22 ±13.73 dB. That showed average hearing loss increased statistically significantly as the duration of disease increased” [19].

MATERIALS AND METHOD

Type of study: Prospective Observational

Place of Study: Department of Otolaryngology and Head Neck Surgery, Uttara Adhunik Medical College Hospital, Dhaka, Bangladesh.

Period of Study: May 2012 – October2012

Study Population: Patients attended the OPD and those who were admitted in otolaryngology and head-neck surgery department of UAMCH, Uttara-Dhaka.

Sample Size: A total of 200 patients (between 14 to 50 years) with perforated tympanic membrane who fulfilled the inclusion criteria in defined period were included in this study.

Sampling method: Non-randomized purposive sampling

Inclusion Criteria

1. Patients with tympanic membrane perforation in pars tensa.
2. Male and female from 14 to 50 years of age.

Exclusion Criteria:

1. Perforation involving the attic region.
2. Presence of active otitis media or otitis externa.
3. Tympanosclerosis.
4. H/O myringoplasty or middle ear surgery.
5. Patients who refused to be included in the study.

Operational definitions

Central perforation:

Perforation at pars tensa where the annulus is present. The annulus is almost invariably present in pars tensa perforations unless it has been previously removed surgically.

Marginal perforation:

Perforation present at pars flaccida. The attribution of the term ‘marginal’ goes along with the absence of an annulus which is not normally present in the attic/ pars flaccid.

The sites of the perforations were grouped as follows (Yung MW 1983): (16)

a) Anterior central: perforation anterior to the handle of malleus.
b) Posterior central: perforation posterior to the handle of malleus.
c) Central malleolar: perforation around the handle of malleus.
d) Big central/ Subtotal: large perforation involving all the quadrants and up to the annulus of the tympanic membrane.

Size of perforation: Perforations are categorized on the basis of surface area of TM involved.

a) Small perforation: involving Up to 25% surface area of the tympanic membrane.
b) Medium perforation: involving 25% -50% surface area of the tympanic membrane.
c) Large perforation: involving >50% surface area of the tympanic membrane.
d) Subtotal / Big central perforation: Only rim of TM present that is the large perforation involving all the quadrants and up to the annulus of the tympanic membrane.
e)

Method of Statistical Analysis

The SPSS software (version 12.0 SPSS, Chicago, Illinois) was used for analysis of the data. Some variables were not normally distributed.

RESULTS

For this study 200 patients were taken both male and female between the age of 14 to 50 with tympanic membrane perforation among which 108 were male and 92 were female. They were categorized according to site and size of tympanic membrane perforation. Hearing threshold was assessed by pure tone audiometry. According to size of perforations, there were small 44 (22%), medium 65 (32.5%), large 48 (24%) and subtotal /big central 43 (21.5 %) perforations. According to location, there were anterior central perforations 28 (14%), posterior central 35 (17.5%), central malleolar 94 (47.0%) and big central / subtotal perforations 43 (21.5%). It was found that patients had perforated tympanic membrane for different durations starting from 0 to >20 years. Duration of perforation was divided into five groups with 5 years group interval. Hearing loss was correlated with site of tympanic membrane perforation, with size of perforation and also with duration of perforation. The results are represented in tables below:

Table 1: Distribution of patients by sex

Sex	Number of patients	Percentage
Male	108	54%
Female	92	46%
Total	200	100%

Table 2: Distribution of patients by the site of perforation

Site of the Perforation	Frequency	Percentage
Anterior Central	**28**	**14.0%**
Posterior Central	**35**	**17.5%**
Central Malleolar	**94**	**47.0%**
Big Central/Subtotal	**43**	**21.5%**
Total	**200**	**100.0%**

Table 3: Distribution of patients by size of the perforation

Size of the Perforation	Frequency	Percentage
Small	44	22.0%
Medium	65	32.5%
Large	48	24.0%
Big Central/Subtotal	43	21.5%
Total	200	100.0%

Table 4: Association between site and size of perforation

Size of the perforation	Distribution of Site of the perforation				Total
	Anterior central f (%)	Posterior central f (%)	Central malleolar (%)	Big central f(%)	
Small	11(25.0%)	13(29.5%)	20(45.5%)	0(.0%)	44(100%)
Medium	10(15.4%)	12(18.5%)	43(66.2%)	0(.0%)	65(100%)
Large	7(14.6%)	10(20.8%)	31(64.6%)	0(.0%)	48(100%)
Subtotal	0(.0%)	0(.0%)	0(.0%)	43(100.0%)	43(100%)
Total	28(14.0%)	35(17.5%)	94(47.0%)	43(21.5%)	200(100%)

Table 5: Average hearing threshold in relation to perforation site

Site of perforation	No of ear	Bone conduction Threshold(dB) Mean ±SD	Air conduction Threshold(dB) Mean ±SD	Air-Bone Gap(dB) Mean ±SD
Anterior Central	28	13.03±3.61	33.48±4.81	20.86±3.73
Posterior Central	35	15.44±7.38	40.64±10.34	25.11±6.42
Central Malleolar	94	13.39±6.41	38.22±9.38	24.71±8.45
Big central/Subtotal	43	17.40±10.62	46.95±12.89	29.56±5.85

Table 6: Average hearing threshold in relation to size of perforation

Size of perforation	No of ear	Bone conduction Threshold(dB) Mean ±SD	Air conduction Threshold(dB) Mean ±SD	Air-Bone Gap(dB) Mean ±SD
Small	44	10.39±3.11	31.24±2.72	20.88±4.13
Medium	65	13.22±5.16	38.41±7.96	25.19±5.07
Large	48	15.66±7.70	43.36±10.81	25.62±5.97
Big Central/ Sub-total	43	17.40±10.62	46.95±12.89	29.56±5.12

Table 7: Hearing threshold of medium size perforation at three locations

Medium Size Perforation	Site of perforation	No of ear/patient	Bone conduction Threshold(dB) Mean ±SD	Air conduction Threshold(dB) Mean ±SD	Air-Bone Gap(dB) Mean ±SD
	Anterior Central	10	13.80±3.60	33.90±4.91	21.10±3.47
	Posterior Central	12	14.92±5.72	42.65±6.00	27.42±2.99
	Central Malleolar	43	12.60±5.28	38.27±8.48	25.52±5.35

Table-8: Association between duration of perforation and hearing threshold

Duration of perforation	No of ear/patient	Bone conduction Threshold(dB) Mean±SD	Air conduction Threshold(dB) Mean ±SD	ABG(dB) Mean ±SD
0-5years	45	11.71±3.53	32.36±2.24	20.65±3.92
6-10years	52	12.36±4.33	35.88±4.85	23.60±5.14
11-15years	53	13.18±3.50	39.74±6.21	26.52±5.22
16-20years	25	16.33±5.27	44.60±8.76	28.25±6.34
>20years	25	17.27±13.09	46.38±14.99	29.19±9.09

Frequency Table

Duration of perforation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	>20years	1	20.0	20.0	20.0
	0-5years	1	20.0	20.0	40.0
	11-15years	1	20.0	20.0	60.0
	16-20years	1	20.0	20.0	80.0
	6-10years	1	20.0	20.0	100.0
	Total	5	100.0	100.0	

No of ear/patient					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25	2	40.0	40.0	40.0
	45	1	20.0	20.0	60.0
	52	1	20.0	20.0	80.0
	53	1	20.0	20.0	100.0
	Total	5	100.0	100.0	

Air conduction Threshold(dB) Mean ±SD					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	32.36±2.24	1	20.0	20.0	20.0
	35.88±4.85	1	20.0	20.0	40.0
	39.74±6.21	1	20.0	20.0	60.0
	44.60±8.76	1	20.0	20.0	80.0
	46.38±14.99	1	20.0	20.0	100.0
	Total	5	100.0	100.0	

Bone conduction Threshold(dB) Mean±SD					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	11.71±3.53	1	20.0	20.0	20.0
	12.36±4.33	1	20.0	20.0	40.0
	13.18±3.50	1	20.0	20.0	60.0
	16.33±5.27	1	20.0	20.0	80.0
	17.27±13.09	1	20.0	20.0	100.0
	Total	5	100.0	100.0	

ABG(dB) Mean ±SD					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20.65±3.92	1	20.0	20.0	20.0
	23.60±5.14	1	20.0	20.0	40.0
	26.52±5.22	1	20.0	20.0	60.0
	28.25±6.34	1	20.0	20.0	80.0
	29.19±9.09	1	20.0	20.0	100.0
	Total	5	100.0	100.0	

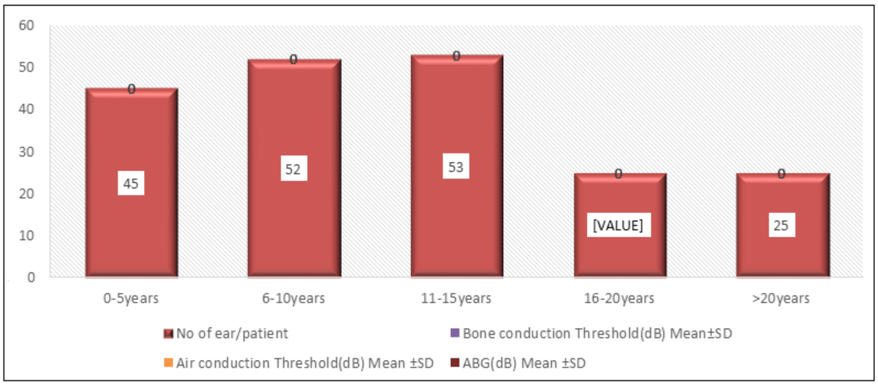

Fig 1: Association between duration of perforation and hearing threshold

DISCUSSION

While considering site of perforation, central malleollar perforation was the highest in number 94 (47.0%) and big central/subtotal perforation was the second highest 43 (21.5%) out of total 200 perforations. While considering size of perforation, medium sized perforation was the highest 65 (32.5%) in number. Except big central/subtotal perforation, association between site of perforation and size of perforation shows that central malleolar site is the most common location for all size of perforations followed by posterior central site. Anterior central site was the least common location of perforations. It was observed that big central /subtotal perforations had highest bone conduction threshold 17.40 ± 10.62 dB, air conduction threshold 46.95 ± 12.89 dB and air bone gap 29.56 ± 5.85 dB. As big central /subtotal perforation involves all quadrants of tympanic membrane and results in loss of nearly whole of pars tensa, it has more deteriorating effect on hearing than any other perforation. In case of air conduction threshold in relation to site of perforation, anterior central perforation had the lowest air conduction threshold 33.48 ± 4.81 dB. Whereas posterior central perforation had air conduction threshold 40.64 ± 10.34 dB (Table 5). In this study, hearing status in case of medium sized perforations (65) at three locations, anterior central (10), posterior central (12) and central malleolar (43) was assessed (Table 7) and was found that posterior central perforation had the highest air conduction threshold in comparison to other two locations. This difference of air conduction threshold shows that posterior central perforation causes more hearing loss than anterior central perforation. This notion is consistent with reports mentioned previously. In relation to size of tympanic membrane perforations, the highest air conduction threshold was 46.95 ± 12.89 dB for big central/subtotal perforation followed by large perforations showing air conduction threshold 43.36 ± 10.81 dB. This was subsequently followed by medium sized perforations 38.41 ± 7.96 dB and small perforations 31.24 ± 2.72 dB. So it has been found that hearing loss increases with the increasing size of the perforation.

It was also found that hearing loss increases with the increased duration of perforation. In case of perforation of 0-5 years, mean air conduction threshold was 32.36 ± 2.24 dB. On the other hand for perforation for 20 years or more mean air conduction threshold was 46.38 ± 14.99 dB.

Limitations of the study

The result of the present study should be interpreted in light of the following limitations. First, size of perforation was determined by visual impression of the observer which might cause some degree of bias that could have affected the findings of the study. Secondly many patients could not mention the exact duration of perforation or ear discharge and the third is that the study sample was small. These limitations should be kept in mind while deciding on the implications of the findings of the study.

CONCLUSION AND RECOMMENDATION

According to the results of this study hearing loss increases with the increasing size of tympanic membrane perforation and posterior central perforation causes more hearing loss than anterior central perforation. It was also noted that hearing loss increases with increased duration of perforation. As tympanic membrane perforation causes significant hearing loss and disability and affect the quality of life, awareness program should be undertaken about this condition by government and non-government organizations to scale up consciousness of the people that will be helpful to reduce the incidence and prevalence of deafness.

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